STATUS OF REPTILES IN UPPER NILGIRIS, NILGIRI BIOSPHERE RESERVE, WESTERN GHATS, INDIA

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In the present paper, we describe species composition, abundance, richness, diversity and biometry of reptiles inhabiting the Upper Nilgiris (1,800-2,400 m above msl), based on *c.* 27 ha of quadrate and 680 man-hours of visual encounter surveys, between October 2000 and September 2002. Including opportunistic observations, 10 species of reptiles were recorded in the area, which includes seven endemics of the Western Ghats. Species richness, diversity, density and relative abundance of reptiles were low in plantations compared to natural habitats. Richness and Diversity are different, the former is actual number of species observed and the latter is an index. The highest density of 14.85 reptiles/ha was found in grasslands and the lowest in pine forests (4.98/ha). The study shows that most of the species inhabiting Upper Nilgiris were affected by conversion of native vegetation into plantations. This study highlights the conservation importance of both habitat (shola and grasslands) and herpetofauna, as both of them are restricted to the Western Ghats.

Keywords: endemic species, Mukurthi National Park, reptile populations, shola, grasslands, Western Ghats

INTRODUCTION

Herpetofauna tends to be an uncommon subject for field studies, compared to birds and mammals (Vitt 1987). This is mainly due to their relatively small size, cryptic nature, seasonal activity and lack of standard sampling protocols. According to Pearman *et al.* (1995), suitability of many herpetofaunal sampling techniques have not been tested and validated in the tropics. It is speculated that several species, including reptiles, are threatened with extinction due to habitat alterations and fragmentations, and also suspected that many species may become extinct even before proper identification and formal reporting. Theoretical conservation plans without understanding species ecology would not yield desired results (Frazier 1992).

The herpetofauna of southern India is one of the most diverse and ecologically poorly known (Inger *et al.* 1987). The Western Ghats is one of the 34 biodiversity hotspots of the world (Mittermeier *et al.* 2005). Several hydroelectric projects have been implemented in this hill range, and many more are in the planning stage. For instance, there are 36 such projects (24 operational, 12 planning stage) only in the Western Ghats of Kerala (Raj *et al.* 2009). Apart from inundation, these projects have severe impact on biodiversity (Sreekumar and Balakrishnan 1998) due to habitat alterations, hunting and dependency on natural resources by settlers. With impetus given by the (Indian) National Forest Policy-1952, major proportion of the grasslands had been converted into exotic plantations of Black Wattle *Acacia mearnsii*, Eucalyptus *Eucalyptus* spp. and Pine *Callitris rhomboidea*. Impacts of these alterations on wild flora and fauna are poorly understood. Taxa such as herpetofauna could be an ideal model to assess these impacts, as they are specific to certain microhabitats of the area. However, precise data even on the distribution of reptiles of Western Ghats is scanty and the available data are limited to lower and medium altitudes (< 1,200 m; Inger *et al.* 1984; Das and Whitaker 1990; Malhotra and Davis 1991; Zacharias 1997; Ishwar *et al.* 2001). In the present paper, we report the species richness, endemicity, diversity, abundance and biometry of reptiles found in Upper Nilgiris. Notes on the impact of plantations on reptiles with respect to species density are also given.

MATERIAL AND METHODS

Study Area

The present study was conducted in Upper Nilgiris (1,800-2,400 m above msl), especially in and around the Mukurthi National Park (11° 10'-11° 22' N; 76° 26'-76° 38' E) of Nilgiri Biosphere Reserve, Western Ghats. The area of this Park is 78.46 sq. km (Fig. 1), and it has relatively undisturbed grasslands interspersed with shola. The isolated, compact, sharply defined forests between the folds of the hills are known as shola, which consist of stunted evergreen tree species (Puri *et al.* 1990). Champion and Seth (1968) classified this as Southern Montane Wet Temperate Forest. Monthly mean temperature of the Upper Nilgiris during this study varied from 15° to 26° C. Cumulative annual rainfall is about 3,000 mm with peak during July. *Dicanthium polyptychum*, *Chrysopogon zeylanicus*, *Fimbristilis* sp. and *Eriocaulon* sp. are common grass species reported from the area.

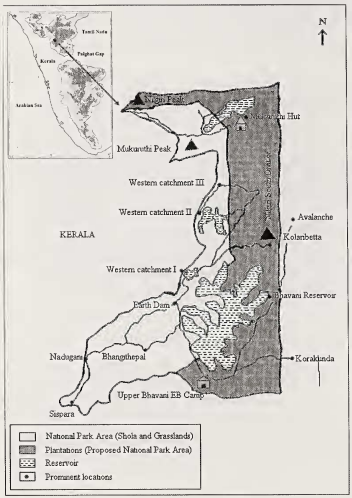

Fig. 1: Mukurthi National Park and its environs, Upper Nilgiris, Western Ghats

In India, till recently, grasslands have not been viewed as wildlife habitat. An estimated 80% of shola and grasslands have been lost in Upper Nilgiris largely to monoculture plantations (Table 1). Exotic species such as Black Wattle, and Pine were introduced during early 1960s (The Nilgiri District Gazetteer 1995). The Wattle plantations in the area were disturbed due to logging operations, as they were most preferred by tanning industries.

Table 1: Comparative account of habitat loss (in sq. km) in Upper Nilgiris, Western Ghats

Habitat	Year	
	1849	1992
Shola	86.0	42.25
Grassland	298.75	47.00
Cultivation	108.75	124.00
Tea	0	114.75
Wattle	0	97.75
Eucalyptus	0	51.50

Source: websits: www.nilgiribiosphereresere.com

Field Methods

A number of herpetofaunal sampling procedures are available in Heyer *et al.* (1994). We used quadrate (10 x 10 m), and visual encounter surveys (VES) for sampling. In both methods, microhabitats, such as bouiders, grass clumps, fallen logs and tree trunks, were examined (Campbell and Christman 1982) for reptiles by two personnel. This facilitated effective detection of most of the reptiles, including the hiding ones. Seasonal and opportunistic observations were also made in and around reservoirs. The study was conducted from October 2000 to September 2002, and the fieldwork was largely restricted to sunlight hours (09:00-16:00 hrs) due to the prevailing cold climate. The monthly mean temperature of Upper Nilgiris has been recorded as 15° to 26° C (Nixon 2005), which is much lower than the preferred body temperature of snakes (28-34° C; Lillywhite 1987) and lizards. Night surveys (18:00-21:00 hrs) when ambient temperature was lower conducted prior to intensive data collection (January-April 2000) also did not yield any reptiles. Snout-vent and tail length of the reptiles were taken using a string and metal ruler (accuracy 1 mm) and weighed using a spring balance (accuracy 0.5 gm). Species identification was following Smith (1935, 1943), and the same was confirmed by comparing specimens deposited at the Collection department of the Bombay Natural History Society, Mumbai. Photographs of species observed are deposited at the Sâlim Ali Centre for Ornithology and Natural History (SACON), Coimbatore, India. Nomenclature followed herein is of Das (2003).

Data Analysis

The following analyses were done.

1. Number of species observed during the study was considered as species richness.
2. Shannon-Wiener species diversity (H') = $-\Sigma\ p_i \ln p_i$, where, p_i = Proportion of total sample belonging to i^{th} species, ln = Natural logarithm.
3. Hill's diversity (N_1) = $e^{H'}$ where, H'= Species diversity.
4. Encounter rate = No. of individuals sighted/total hours surveyed.
5. Density = No. of individuals sighted/ area sampled.
6. Relative abundance = $(n/N)100$, where n is number of individuals of a species observed, and N is the total number of all species observed.
7. Impact of plantations on the reptile species $(I) = (d_p - d_n)100/d_n$, where d_n = Density of species in shola and grasslands (natural habitat), d_p = Density of species in plantations.

Table 2: Detection of reptiles using quadrate samples in Upper Nilgiris

Habitat	Quadrates examined	Quadrates with reptiles	No. of species observed	No. of individuals	No. of reptiles/ ha
Grassland	840	52 (6.2%)	7	125	14.9
Shola	345	11 (3.2%)	2	51	14.6
Wattle	840	42 (5%)	5	69	8.2
Pine	201	4 (4%)	2	10	6.9
Tea	480	27 (5.6%)	3	27	5.6
Total	2,706	136 (5.03%)	7	282	10.42

RESULTS

A total of 2,706 quadrates (*c.* 27 ha) and 680 man-hours of visual encounter surveys have been conducted in various habitats (shola, grassland, wattle, tea, pine) of the Upper Nilgiris from October 2000 to September 2002. Data from quadrate sampling was used for estimating species density and quantify the impact of habitat alterations on reptiles. Data obtained from both methods were pooled for all other analyses.

Species Richness and Diversity

Including opportunistic observations, 10 species of reptiles have been recorded in Upper Nilgiris (1,800-2,400 m). This includes one species each of Agamid Lizard *Salea horsfieldii*, Day Gecko *Cnemaspis indica* and Skink *Kaestlea bilineata*, and seven species of snakes: *Plectrurus perroteti*, *Xylophis perroteti*, *Ahaetulla perroteti*, *Oligodon venustus*, *Xenochrophis piscator*, *Ptyas mucosa* and *Protobothrops strigatus*. Among them, barring three species, *Protobothrops strigatus*, *Ptyas mucosa* and *X. piscator* all were endemic (70%) to the Western Ghats. The native habitats (shola and grassland) had only seven species, including six (87.5%) endemics. *P. mucosa*, *X. perroteti* and *X. piscator* have not been observed in natural vegetations.

Sampling intensity and detection of reptiles in quadrate and VES are given in Tables 2 and 3. The highest number of species and individuals were observed in VES (8 species, 593 individuals) compared to quadrates (7 species, 282 individuals). In 2,706 quadrates examined in various habitats, on an average only 5% of the quadrates had reptiles; maximum (6.2%) in grasslands and minimum (3.2%) in shola. In 680 hours of VES, the highest detection of 1.87 reptiles/hr was found in grasslands and the lowest (0.38/hr) in Tea plantation (Table 3).

Table 3: Detection of reptiles using visual encounter surveys in Upper Nilgiris

Habitat	No. of hours searched	No. of species observed	Individuals recorded	Reptiles/hr
Grassland	156	6	292	1.87
Shola	230	5	115	0.50
Wattle	144	7	121	0.84
Pine	30	2	19	0.63
Tea	120	4	46	0.38
Total	680	8	593	0.87

Table 4: Reptile species richness and diversity in various habitats of the Upper Nilgiris

Description	Grassland	Shola	Wattle	Pine	Tea
Species richness (N)	7	5	7	2	4
Species diversity (H')	1.24	0.34	1.23	0.21	0.66
Hill's diversity	3.5	1.4	3.4	1.2	1.9

Table 4 provides data on the diversity of reptiles observed in Upper Nilgiris. The highest species richness and diversity was observed in grasslands, whereas pine plantation had the lowest. Among plantations, Black Wattle had the highest species richness and diversity. The Hill's diversity ($e^{H'}$) provides an index of number of contributing species to the diversity or community. Similar to the data of Shannon-Wiener Index, the highest of 3.5 contributing species was found in grasslands followed by wattle, and lowest (1.2) in pine plantation.

Density, Relative Abundance and Biometry

Overall, reptile density was high in the natural habitats (grasslands and shola) compared to plantations (wattle, pine and tea). The highest of 14.85 reptiles/ha was found in grasslands followed by shola (14.6/ha) and the lowest in pine (4.98/ha). Density of lizards was high compared to snakes (Table 5). *S. horsfieldii* had the highest density (13.7/ha) followed by *C. indica* (9.4/ha) in one habitat. Of the eight species observed, five had the highest density in grasslands, two in shola and one in wattle; seven out of eight species had high density in natural habitats compared to plantations.

Relative abundance of reptiles of Upper Nilgiris was calculated based on 875 observations. Relative abundance of *C. indica* was the highest (43.2%) followed by *S. horsfieldii* (36.46%). *X. perroteti* had the lowest relative abundance among all reptiles found in the samples (0.34 %). Abundance of snakes was low compared to lizards (Fig. 2) and among snakes, *A. perroteti* (5.03%) and *P. perroteti* (4%) were relatively high.

Biometry data of eight species of reptiles found in the samples of Upper Nilgiris are given in Table 6. The largest species observed in the area with respect to snout-vent length was *S. horsfieldii* in lizards and *A. perroteti* in snakes, and *C. indica* and *P. perroteti* were the smallest, respectively.

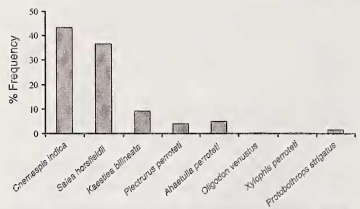

Fig. 2: Relative abundance of reptiles based on 875 observations in Quadrate and Visual Encounter Surveys in Upper Nilgiris, Western Ghats

Snakes were heavier compared to lizards and *X. perroteti* was the heaviest species of reptile observed during this study.

Impact of Habitat Alterations

The natural vegetations, shola and grasslands are contiguous, and most of the grasslands were converted into plantations in the past (Table 1). Hence, data from shola and grassland (natural habitat) and plantations (modified/ altered habitats) were pooled to know the impact of plantations, if any, on reptiles in a broader scale. Of the eight species observed, six had high negative impact (>40%) for plantations. Only two species (*K. bilineata* and *X. perroteti*) had positive values when natural vegetations were altered (Table 7). The present results suggest that most of the species inhabiting Upper Nilgiris were affected by habitat alterations.

DISCUSSION

A total of 120 reptile species have been reported from the Nilgiri Biosphere Reserve (NBR), which includes forest areas from Karnataka, Kerala and Tamil Nadu extending over 5,000 sq. km (Daniels 1993). The Nilgiri District Gazetteer (1995) indicates the occurrence of 86 species in the district. Rich assemblage of reptile fauna in NBR could largely be due to its larger geographical spread, diverse topography (300-2,600 m above msl) and climatic conditions. Apart from smaller area, colder conditions could be one of the major reasons for the poor representation of reptiles (10 species) in the present study area. Similar to the present observations, fewer reptile species have been reported from colder and high altitudes (Rogers 1976; Scott 1976; Heatwole 1982). In colder conditions, the existence of only cold-hardy species is possible. As stated earlier, monthly mean temperature during the study period ranged from 15° to 26° C (Nixon 2005), which is much lower than the optimal body temperature of many species of snakes (28-34° C; Lillywhite 1987). From our observations, ambient temperature appears to be one of the major factors determining the richness of reptiles in higher altitudes.

Ptyas mucosa, *Xylophis perroteti* and *Xenochrophis piscator* have not been observed in natural vegetations, and the former (two) species were observed only in plantations and reservoirs, respectively. *P. mucosa* and *X. piscator* are non-endemics and are relatively common in plains. We presume that *P. mucosa* has reached the high altitudes through plantations. The plantations might have provided ideal habitats for invading rodents (Shanker and Sukumar 1999) that in turn could have formed prey base for *P. mucosa*, which is predominantly a rodent feeder. Invasion of this species to the higher altitudes have also been reported in Sri Lanka (de Silva 1999). *X. piscator* might have reached the Upper Nilgiris through water conducting systems built by the Tamil Nadu Electricity Board. It is not clear as how these species that largely inhabit low hills and plains thrive in colder conditions. Studies on the adaptability of species distributed in colder conditions would provide more insights pertinent to the impact of global warming in relation to species movement from relatively warm lower altitudes to cooler higher altitudes and vice-versa.

Table 5: Density of reptiles in various habitats of the Upper Nilgiris, Western Ghats

Species	Grassland (8.4)	Shola (3.45)	Wattle (8.4)	Pine (2.01)	Tea (4.8)
Cnemaspis indica (Gray, 1846)	9.4	0	2.86	0	0
Salea horsfieldii (Gray, 1845)	1.19	13.7	3.9	4.5	5
Kaestlea bilineata (Gray, 1846)	1.4	0	1.19	0.5	0.42
Plectrurus perroteti (Dumeril, Bibron & Dumeril, 1854)	1.19	0	0	0	0.21
Ahaetulla perroteti (Dumeril, Bibron & Dumeril, 1854)	1.07	0	0.12	0	0
Oligodon venustus (Jerdon, 1853)	0.24	0	0	0	0
Xylophis perroteti (Dumeril, Bibron & Dumeril, 1854)	0	0	0.12	0	0
Protobothrops strigatus (Gray, 1842)	0.36	0.86	0	0	0
Overall density (ha)	14.85	14.6	8.2	4.98	5.6

Data in parentheses indicate area sampled

Table 6: Biometry of reptiles observed in the Upper Nilgiris, Western Ghats

Species	Snout-vent length	Tail length	Weight
Cnemaspis indica (202)	30 ±6	29 ±11	1.6 ±0.65
Salea horsfieldii (310)	549 ±15	120.4 ±43	6.5 ±3.8
Kaestlea bilineata (77)	44 ±11	55 ±21	3.3 ±1.0
Plectrurus perroteti (34)	167 ±53	10 ±4	6.4 ±3.2
Oligodon venustus (3)	272	34	13.5
Xylophis perroteti (6)	288 ±139	37 ±34	19.4 ±18.8
Ahaetulla perroteti (44)	310.2 ±66	109 ±26	18.07 ±8.04
Protobothrops strigatus (12)	244 ±70.4	35 ±8	17.2 ±10.5

± is Standard Deviation; SVL-snout vent length,
tL-tail length in cm and weight (wt) in gram;
Number in parentheses indicates sample size

Table 7: Impact of habitat alterations (natural vegetations to plantations) on the density reptiles in Upper Nilgiris

Scientific name	Natural habitats (d_n)	Plantations (d_p)	Impact (I) (%)
Cnemaspis indica	4.70	1.43	-69.6
Salea horsfieldii	7.45	4.46	-40.1
Kaestlea bilineata	0.71	0.80	+12.7
Plectrurus perroteti	0.6	0.10	-83.3
Xylophis perroteti	0	0.06	+
Oligodon venustus	0.12	0	-100
Ahaetulla perroteti	0.54	0.06	-88.9
Protobothrops strigatus	0.61	0	-100
Overall density	14.7	6.92	-52.9

Heyer *et al.* (1994) suggested using various herpetofaunal sampling methods to maximize the output, however, many of them are largely untested in tropics (Pearman *et al.* 1995). Data obtained using VES and Quadrate differed in quality, number of reptiles/ hour and number of reptiles/ ha. Higher number of species and individuals were observed in VES during this study. It is reported that visual encounter survey is suitable for sampling rare or trap-shy species (Crump and Scott 1994), which is augmented by Doan (2003) and the present study.

Inger (1980) found greater herpetofaunal richness in logged forests and plantations compared to rainforests and suggested that this may be due to environmental factors. In the present study, number of species and diversity was high in grasslands followed by wattle. The wattle plantations found in the study area were logged and the canopy cover was low compared to pine and shola. The Pine plantations had thick canopy cover and the temperature inside was 2-3° C lower at any given point of time (Nixon 2005) compared to grassland and wattle. Information on density, relative abundance and biometry of the reptiles are scanty in India and the present data would form baseline in this regard.

Habitat alterations may have both positive and negative impacts (Vitt *et al.* 1998; Dickerson 2001). In the present study, out of eight species found in the quadrate samples, only *Kaestlea bilineata* and *Xylophis perroteti* got marginal positive impact due to plantation (Table 7). However, species richness, diversity, density, and relative abundance of many species were low in plantations. This study highlights the conservation importance of both habitat (shola and grasslands) and herpetofauna, as both of them are restricted to the Western Ghats.

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